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ORIGINAL ARTICLE

Can Functional Capacity Tests Predict Future Work Capacity in Patients With Whiplash-Associated Disorders?

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Abstract

Objective: To determine whether functional capacity evaluation (FCE) tests predict future work capacity (WC) of patients with whiplash-associated disorders (WADs) grades I and II who did not regain full WC 6 to 12 weeks after injury.

Design: Prospective cohort study.

Setting: Rehabilitation center.

Participants: Workers (N=267) listed on workers' compensation with grade I or II WADs 6 to 12 weeks after injury.

Interventions: Patients performed 8 work-related FCE tests.

Main Outcome Measures: WC (0−100%) measured at baseline and 1, 3, 6, and 12 months after testing. Correlation coefficients between FCE tests and WC were calculated. A linear mixed-model analysis was used to assess the association between FCE and future WC.

Results: Mean ± SD WC increased over time from 20.8%±27.6% at baseline to 32.3%±38.4%, 51.3%±42.8%, 65.6%±42.2%, and 83.2%±35.0% at the 1-, 3-, 6-, and 12-month follow-ups, respectively. Correlation coefficients between FCE tests and WC ranged from $r=.06$ (lifting low at 12-mo follow-up) to $r=.39$ (walking speed at 3mo). Strength of the correlations decreased over time. FCE tests did not predict WC at follow-up. The predictors of WC were ln (time) ($\beta=23.74$), mother language ($\beta=5.49$), WC at baseline ($\beta=1.01$), and self-reported disability ($\beta=-.20$). Two interaction terms, ln (time) × WC ($\beta=-.19$) and ln (time) × self-reported disability ($\beta=-.21$), were significant predictors of WC.

Conclusions: FCE tests performed within 6 to 12 weeks after WADs injury grades I and II are associated with WC at baseline but do not predict future WC, whereas time course, mother language, WC at baseline, and self-reported disability do predict future WC. Additionally, the interaction between time course WC at baseline and self-reported disability predicted future WC.

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The prognosis of whiplash-associated disorders (WADs) varies substantially within the population, with recovery rates of 40% to 60% within the first year. Many individuals with WADs report symptoms and disability 1 year after the initial injury.[1,2] Because of long-term work absence and disability, delayed recovery from WADs causes a substantial burden to individuals and society.[3] Several studies[4,5] have investigated prognostic factors for the clinical course of WADs. Established prognostic factors include postinjury pain intensity and self-reported disability.[1] Psychosocial factors such as fear of movement, self-efficacy beliefs, poor recovery expectation, pain catastrophizing, passive coping, and depression predict poor recovery.[2,4,6,7] Studying the prognosis of whiplash is complicated, and the validity of previous

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studies has been limited by small sample size, inclusion of patients >6 months after injury onset, short follow-up periods (<6mo), loss to follow-up, unblinded outcome assessors, and lack of statistical adjustment for important covariates.[8]

Because of a weak association between self-reported and objectively measured function in patients with chronic pain,[9] the use of both self-reported and objectively measured data for a comprehensive assessment of (work-related) illness status is recommended.[10] Functional capacity evaluation (FCE) consists of batteries of standardized tests to evaluate an injured worker's functional capacity and ability to perform work-related activities.[11] When FCE results indicate that a worker's functional capacity is less than the job's physical demands, a rehabilitation program can be proposed to improve the ability to return to work (RTW).[12,13] FCEs are also used to guide case closure.[14,15] However, the prognostic ability of FCE for RTW is not known for patients with WADs. As such, this study aimed (1) to determine the predictive ability of FCE tests to determine future work capacity (WC); and (2) to develop a predictive model for WC in a cohort of patients with WADs grades I and II who did not regain full WC 6 to 12 weeks after injury. Our hypotheses were that FCE tests independently predict WC in the short-term and that the predictive ability of FCE tests decreases over time.

Methods

Study design

A prospective cohort design was used for this study.

Context, subjects, and data collection

Participants were recruited from the German-speaking part of Switzerland. They all were insured by the Swiss Accident Insurance Fund (SUVA). SUVA is the largest state-owned accident insurance fund in Switzerland and covers occupational and nonoccupational injuries for employed individuals, mainly in labor industries, and unemployed job-seeking persons.[16] Injured persons receive compensation up to a maximum of 80% of their previous salary, and medical and vocational assistance. If health status is stabilized but disabilities remain, long-term invalidity pensions are refunded by SUVA and the invalidity insurance. Between January 2011 and January 2012, insurance physicians or case managers of SUVA referred eligible participants for an interdisciplinary rehabilitation assessment at the rehabilitation clinic in Bellikon (Switzerland). The main reasons for referral included (1) not regaining full WC within 6 to 12 weeks after a whiplash injury; (2) exceeding expected healing times; (3) or having plateaued with the provided medical and rehabilitative care. Inclusion criteria for this study were (1) neck pain caused by WADs according the Québec Task Force Classification—grade I (pain, stiffness, or tenderness without physical signs) or grade II (pain, stiffness, or tenderness with decreased range of motion and point tenderness); (2) WC<100% of the previous job at the time of the FCE; (3) sufficient German language skills to communicate with the FCE assessors and to respond to questionnaires in German, Albanian, Serbo-Croatian, Italian, Portuguese, or Spanish; (4) ages 18 to 65 years; and (5) willingness to participate. In total, 427 subjects were referred to the interdisciplinary assessment. Of those, 160 were not eligible: 79 (48%) did not have WADs; 46 (28%) had a WC of 100%; 17 (10%) had insufficient German language skills or were unable to complete the questionnaires; 6 (4%) had other medical reasons; 5 (3%) had acute comorbidity that limited testing (fracture or severe psychiatric disorder); 3 (2%) were younger than 18 years or older than 65 years; 2 (1%) had WADs grade III or IV; and 2 (1%) were pregnant.

All participants agreed to participate in this study. The Medical Ethics Committee of Canton Aargau granted ethical approval for this study (EK AG 2010/055).

List of abbreviations:

FCE	functional capacity evaluation
HADS	Hospital Anxiety and Depression Scale
IQR	interquartile range
NDI	Neck Disability Index
RTW	return to work
S_{ED}	submaximal effort determination
SFS	Spinal Function Sort
SUVA	Swiss Accident Insurance Fund
WAD	whiplash-associated disorder
WC	work capacity

Procedure

A rehabilitation physician performed a review of the medical history and a physical examination (approximately 60min), followed by FCE tests administered by a physiotherapist. After determination of eligibility, patients completed questionnaires and carried out FCE tests (60min). This was followed by a brief educational intervention and a trial therapy that included a combination of strength exercises, education (ergonomic), and home exercises. The interdisciplinary rehabilitation assessment ended with a face-to-face discussion with the patient about strategies to facilitate recovery. Fitness-for-work certificates or WC settlements were explicitly not part of this interdisciplinary assessment.

FCE assessors

A sample of 21 physiotherapists (11 women) from the rehabilitation clinic served as FCE assessors. Nineteen had attended a 2-day FCE training course of the Swiss Association of Rehabilitation.[17] Before the study, all had performed at least ten 1-day FCEs in the previous year (median, 30; interquartile range [IQR], 20–33), had a minimum of 1-year experience in work rehabilitation (median, 3; IQR, 2–3), and had a minimum professional practice experience of 1 year (median, 5y; IQR, 3–12.5). In this study, inter- and intratester reliability of the FCE assessors was good for the 2-point scale used to determine submaximal effort.[18]

Measures

Outcome variable

WC was used as a measure of ability to work. WC was assessed at baseline and at the 1-, 3-, 6- and 12-month follow-ups. WC was determined by the treating physician, usually a general practitioner, and represents the proportion ability to work regarding the preinjury work. Estimation of WC may be determined by suggested measures of WC and based on current national guidelines.[19,20] WC is expressed in a percentage (0–100%) and is translated into days or hours of modified work. For example, if a worker is deemed to have a WC of 50%, he/she will work for 2.5

days per week or 5 half days per week of modified work. The remaining 50% is financially compensated. The WC was obtained from the accident insurance's administrative data. The reliability and validity of the WC assessment conducted by physicians are unknown.

Predictor variables

Patient characteristics and probable predictors influencing recovery were recorded before FCE and included age, sex, body mass index, marital status, mother language, duration since injury, number of previous injury claims, litigation, percentage at work, job contract, education status, and physical work demands. Potential predictor variables were selected based on previous studies[1,4] and clinical experience.

The FCE used in this study (WADs FCE) consisted of 8 tests, based on the Isernhagen Work System (now known as WorkWell FCE)[11]: handgrip strength right-handed, lifting floor to waist, lifting waist to overhead, short 2-handed carry, long carry right-handed, overhead working, repetitive reaching right-handed, and walking speed (50-m walking test). Test details are described in appendix 1. Reliability of WADs FCE tests is good to excellent, and the tests are safe.[21]

Pain intensity was measured with an 11-point numeric rating scale ranging from no pain (0) to worst pain (10).[22] Patients were asked to rate their momentary pain (pain now), worst pain (pain maximum), and mildest pain (pain minimum) during the last week. The numeric rating scale has demonstrated reliability and validity in patients with neck pain.[23]

Perceived recovery (recovery question) is a categorical global self-assessment using the question "How well, do you feel, you are recovering from your injuries?", with the following response options: (1) all better (cured); (2) feeling quite a bit of improvement; (3) feeling some improvement; (4) feeling no improvement; (5) getting a little worse; and (6) getting much worse. We defined participants as "(somehow) improved" when they reported feeling "all better", or "feeling quite a bit of improvement", or "feeling some improvement."[24] The recovery question was asked by the rehabilitation physician before the FCE tests; the recovery question was found reliable in patients with WADs.[25]

Neck pain−related disability was measured with the Neck Disability Index (NDI). The NDI contains 10 items: pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. The scale of each item ranges from no disability (0) to total disability (5). Higher NDI scores indicate more disability. The NDI is reliable and deemed valid.[26]

The Hospital Anxiety and Depression Scale (HADS) was used to assess the symptom severity of anxiety disorders and depression in the nonpsychiatric population. The HADS consists of 2 subscales, one for anxiety and one for depression (A and D subscales). Each scale contains 7 items, with each item rated from 0 (best) to 3 (worst). The scale scores are calculated by summing the responses up to a maximum score of 21 points (severe case) per scale. Good reliability, validity, and excellent screening properties have been reported for the use of the HADS in the general and clinical populations.[27]

The Spinal Function Sort (SFS) was used to capture perceived functional ability for work tasks. This questionnaire contains 50 drawings with simple descriptions. Participants rated functional ability for each activity from "unable" (0) to "able" (4). The SFS yields a single rating ranging from 0 to 200, with higher scores indicating better abilities. The scores can be categorized according to the work demands as defined by the *Dictionary of Occupational Titles*,[28] allowing a comparison between self-reported functional ability and work demands. The SFS has a good reliability and high predictive validity for non-RTW in patients with back pain.[29,30]

Submaximal effort determination (S_{ED}) was assessed when a patient stopped a FCE test *before* the FCE rater observed sufficient criteria indicative of maximal weight, or significant functional problems/limitation. The rating of S_{ED} has shown high inter- and intrarater reliability in patients with chronic musculoskeletal pain.[18] A S_{ED} score is the number of FCE items of the total FCE items performed with submaximal effort. A submaximal effort index (SMI) was derived by dividing the total number of FCE items performed submaximally by the 8 FCE tests performed $\times$ 100% (SMI=[n tests submaximal/8]$\times$100%).

Data analysis

Descriptive statistics were computed for baseline patient characteristics and outcome variables. Where appropriate, PP or QQ plots were visually assessed for normality of data. At follow-up, bivariate correlations were calculated between FCE tests and WC; a linear mixed model was used to determine the predictive value of FCE tests for WC while controlling for confounders.

Collinearity between FCE tests and predictors was checked before the model was built.

The analysis included the following steps:

- *Step 1:* All 8 FCE tests and the S_{ED} were entered as predictors in the model with WC at the 1-, 3-, 6-, and 12-month follow-ups as outcome variables (results not shown; available on request). No other predictors were entered in step 1. Regression coefficients with a P value ≥ 0.1 were not considered in the following steps of the analysis. Fixed- and random-effects models were analyzed.
- *Step 2:* In addition to the remaining FCE tests ($P<0.1$) in the model, a random-effect coefficient was added to the model, which accounted for the effect of predictors and may differ between participants. We observed an increase of WC over time. Time after baseline assessment was transformed as follows: we took the natural logarithm of the weeks after baseline + 1 week (ln weeks+1); the value was entered as a predictor in the model.
- *Step 3:* Together with time course (ln weeks), 18 potential predictor variables (described in the section "Predictor Variables") were entered in the model one by one. If the regression coefficients of the remaining FCE tests variables changed by >10%, the predictor variable was retained for the next step.
- *Step 4*: The remaining FCE tests and the remaining predictor variables from step 3 were simultaneously entered into the model. The variables were then excluded manually in a backward selection procedure. Predictors were removed from the model if the model fit (−2LogLikelihood) did not decrease significantly or the regression coefficient was not significant ($P>.05$). Finally, 2-way interactions between the predictors that were significantly related to the outcome variable and the time course were explored. Residuals of the linear mixed-model analyses were plotted in a graph and visually assessed for normality. Data were analyzed in SPSS version 21.0.[a]

Table 1 Baseline characteristics of patients (N=267)

Characteristics	Values
Age (y)	36.0 (27.0–44.0)
Sex: female	106 (39.7)
BMI, [2]	26.0 (23.0–30.0)
Marital status	
Married or cohabitation	137 (51.3)
Single	93 (34.8)
Divorced or living separated	36 (13.5)
Other (eg, widowed)	1 (0.4)
Mother language	
German	131 (49.1)
Other*	136 (50.9)
Duration since WAD injury claim opening (d)	90.0 (71–122.0)
No. of injury claim openings previous to current WAD injury	2.0 (0.0–5.0)
Attorney involved	75 (28.1)
Work capacity in % of the actual or previous work (if jobless)	0.0 (0.0–50.0)
Work status: job contract†	210 (78.7)
Education‡	
Low	129 (48.3)
Intermediate	132 (49.4)
High	6 (2.2)
Physical work demands§	
Sedentary to light (<5–10kg)	89 (33.3)
Medium (11–25kg)	97 (36.3)
Heavy to very heavy (26 to >45kg)	81 (30.3)
FCE tests	
Hand grip strength (kgF)	33.3±14.9
Lifting floor to waist (kg)	18.6±10.0
Lifting waist to overhead (kg)	11.2±5.8
Short carry 2-handed (kg)	23.0±12.1
Long carry 1-handed (kg)	16.5±7.3
Overhead working (s)	166.0 (94–300)
Repetitive reaching (s), [1]	82.0±26.6
50-m walking test (km/h)	5.1±1.2
Submaximal effort score (S_{ED} 0–8), no. of items, [1]	2 (0–8)
Self-reported measures	
Pain now (NRS, 0–10)	5.0 (3.0–6.0)
Perceived recovery (RQ), n of "somehow improved"‖ (%)	186 (69.7)
Perceived functional ability (SFS, 0–200), [5]	136.0 (99.5–163.0)
Disability (NDI, 0–50)	23.4±7.9
Anxiety (HADS-A, 0–21)	9.0 (6.0–13.0)
Depression (HADS-D, 0–21)	7.0 (4.0–10.0)

NOTE. Values are median (IQR), n (%), or mean ± SD. Data that have a skewed distribution are expressed as median (IQR). [n]=missing data. Abbreviations: BMI, body mass index; NRS, numeric rating scale; RQ, recovery question.

* Other: 75 (28.1%) Albanian, 23 (8.6%) Serbo-Croatian, 14 (5.2%) Italian, 8 (3.0%) Turkish, 7 (2.6%) Arabic, 3 (1.1%) Portuguese, 1 (0.4%) Spanish, 5 (1.9%) various; mother language was used as term as a proxy for cultural background or nationality.[34]

† Job contract: has a running job contract (≠jobless).

‡ Level of education: low, no vocational education; intermediate, vocational education; high, bachelor or higher education.

§ Maximum physical work load of material handling tasks in the previous job according to the *Dictionary of Occupational Titles* (DOT). DOT categories were merged into 3 categories.

‖ "Somehow improved" was assumed when the patient scored 1 to 3 on the 6-point scale of the recovery question.

Results

Descriptive statistics of study population

A total of 267 patients were included. Patient characteristics are displayed in table 1.

Mean WC ± SD was 20.8±27.6 at baseline and 32.3±38.4, 51.3±42.8, 65.6±42.2, and 83.2±35.0 at the 1-, 3-, 6-, and 12-month follow-ups, respectively (fig 1). In a post hoc analysis, we compared the patients' WC and corrected for the region of the insurance to which they were referred; no regional differences were observed.

Bivariate analysis

Correlation coefficients between FCE tests and WC decreased over time for most variables (fig 2). The correlation coefficients ranged from r=.06 (lifting low at 12-mo follow-up) to r=.39 (walking speed at 3mo). At follow-up, walking speed and S_{ED} showed the highest correlations with WC.

Mixed-model analysis

The results of the mixed-model analysis for all follow-up times at the 1-, 3-, 6-, and 12-month follow-ups are presented in table 2. In step 1, the following 3 FCE tests predicted WC: repetitive reaching, walking speed, and the SED score (data from step 1 are available on request). The regression coefficients of the 3 FCE tests in the model decreased from step 2 to step 3 by −.05 for repetitive reaching, −5.45 for walking speed, and −1.76 for S_{ED} score. From all 18 predictor variables, 9 (age, sex, body mass index, marital status, duration since injury, attorney involved, work status, education, physical work demands) did not change regression coefficients of the 3 FCE test variables by >10% and were therefore not considered for the next step. In step 4, the remaining 9 predictor variables (WC at baseline, mother language, number of prior injuries, pain level, perceived recovery, perceived functional ability, disability, anxiety, depression), together with the 3 FCE tests and ln (weeks+1), were entered in the model (see table 2, step 3). None of the FCE tests remained significant predictors of future WC. Therefore, FCE tests were excluded from the final model. The final prognostic model included ln (weeks+1) (β=23.74), mother language (β=5.49), WC at baseline (β=1.01), and self-reported disability (β=−.20). All the 2-way interactions between these 4 predictors were explored. Two interactions terms were significant: Time course mediates WC and self-reported disability, as those 2 interaction terms remained significant. Overall, time course and mother language were the predictors with the highest regression coefficients. To facilitate interpretation of the results of the linear mixed-model analysis, 2 clinical examples were calculated (appendix 2).

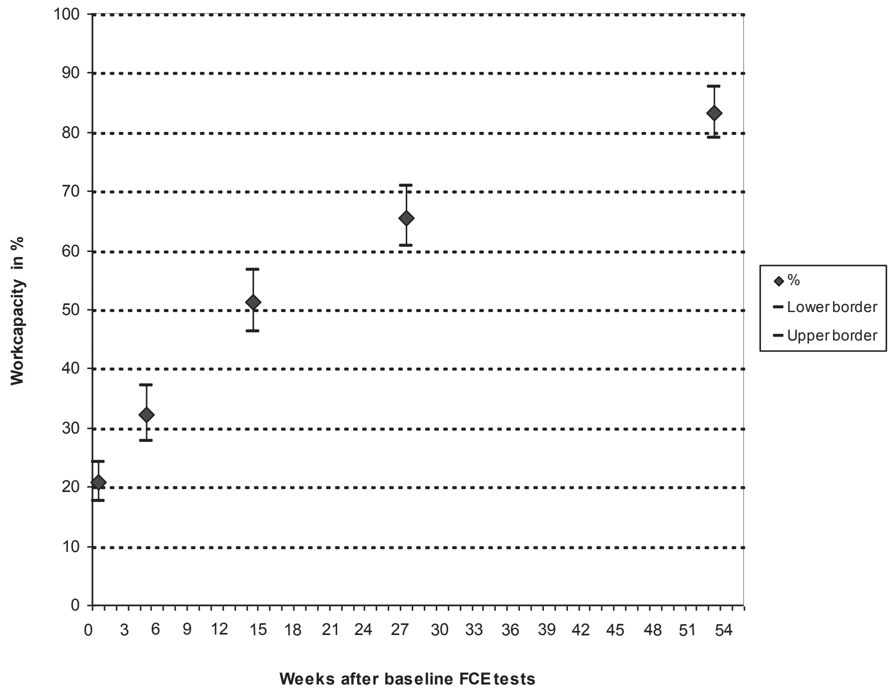

Fig 1 Mean WC of participants at 0, 1, 3, 6, and 12 months' follow-up.

Discussion

We conducted a prospective cohort study to determine the prognostic ability of FCE tests to predict WC, and developed a predictive model in a cohort of patients with WADs. Correlation coefficients between FCE tests and WC were <0.4 at baseline and decreased over the follow-up period. In the multivariate model, outcomes of FCE tests do not predict future WC. Our final model suggested that the strongest predictors were time course, mother language, baseline WC, and self-reported disability.

We recommend monitoring variables with the best predictive capacity in those patients who fail to improve in the transition from the acute to the chronic stage of the disorder.[31] Values of the prognostic variables identified in this study can easily be recorded.

In addition to WC at baseline, NDI scores and mother language were independent predictors. Whereas the NDI was also predictive in other populations and settings, the importance of the mother language may be specific for this rehabilitation setting.[29,32] Immigrants with different mother languages (ie, cultural backgrounds) form a large part of the workforce in Europe and the United States. These populations are deemed vulnerable and seem more exposed to adverse working conditions.[33,34] Moreover, these groups may have different expectations concerning RTW, which could lead to a higher dropout rate from rehabilitative interventions.[35] In this study, they represented 50% of patients. Although, studies about the role of the mother language are scarce, 1 study[36] reported that the mother language, among others, was a predictor for non-RTW. Additionally, a non-Swiss mother language is related to a low health literacy, which may cause a substantial burden to society and the injured person.[37] Understanding the role of language in the development of chronic WADs may be crucial for developing effective work disability prevention programs for patients with WADs.

Predicting RTW in patients with chronic pain is difficult. Lifting tests explain 10% to 20% of the variance in RTW in patients with musculoskeletal disorders.[38] Some authors reported an explained variance up to 27%,[39] while others suggested that adding FCE tests to self-reported data would increase the explained variance from 9% to 16%.[40] However, others reported a 10% explained variance, questioning the predictive value of FCE tests for RTW in patients with chronic musculoskeletal pain.[41,42] These differences may be explained by differences in study design (eg, cross-sectional vs prospective) or sample size ranging from 5 to 20 events per prognostic association tested. Follow-up times may range from 1 to 12 months, statistical models may use uni- or multivariate analysis that corrects for confounders.[8] Moreover, results between studies may differ based on the definition of RTW used, which can be measured by self-report or insurance data. Also social security systems between different countries may lead to different results. This study shows that the strength of the correlation between WC and FCE tests is related to the time point after the whiplash injury.

Most of the patients in this study reached full WC within the 12-month follow-up period. This is in contrast to other studies[1,2] showing that a substantial proportion of patients with WADs (40%–60%) still have varying levels of pain and self-reported disability after 1 year. We hypothesized that WC over 12 months may not be indicative of perceived disability. In a post hoc analysis, we evaluated the correlation between WC and the available NDI scores at 3 and 12 months (50% of the study sample). The correlations were low ($r<0.3$; WC accounts for 9% of the explained variance of NDI), indicating that disability and WC are related but distinct constructs.

While it may be methodologically correct to study FCE tests separately, in clinical work, FCE tests are used in conjunction

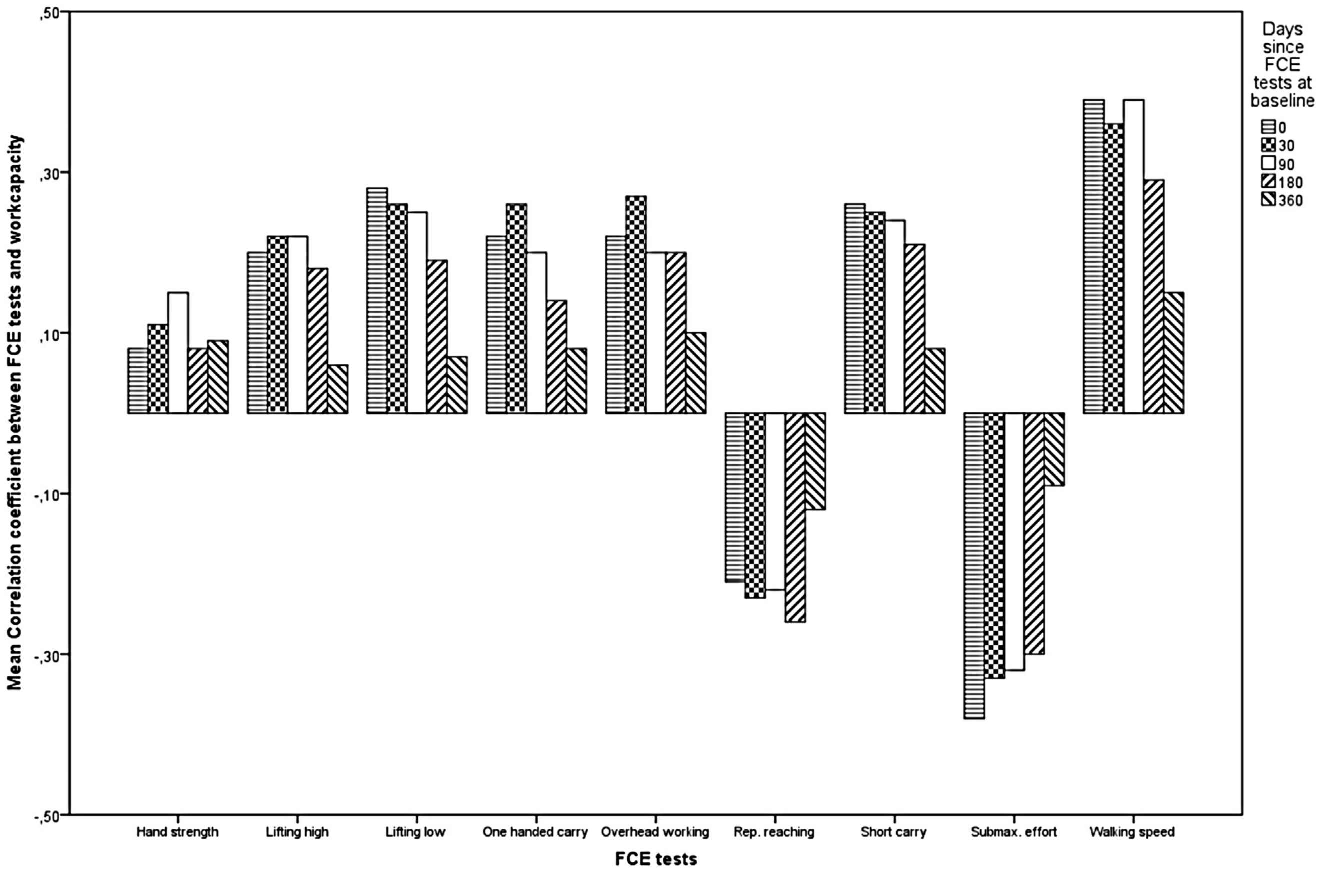

Fig 2 Bivariate correlations (Pearson correlations, except for overhead working and submaximal effort, Spearman rank correlation was used) between FCE tests and WC at baseline, 30, 90, 180, and 360 days' follow-up. For repetitive reaching and submaximal effort score, correlations coefficients were negative (negative values were positively transformed in this figure). Abbreviations: Rep, repetitive; Submax, submaximal.

with medical records, patient interviews, musculoskeletal evaluation, and job-specific observations.[11] One may argue that predictive values would be higher if RTW can be predicted based on the full clinical package, including FCE tests. Results of this strategy are indeed positive.[43,44] However, methodological challenges accompany this as well.[45,46] Whether an FCE-related interview alone may be an option for FCE tests to predict future WC in patients with WADs is unknown.[47] Since participants were referred because of insufficient recovery, malingering and secondary gain might be an issue. In FCE testing, malingering and secondary gain may be linked to submaximal performance during the FCE test.[48] Submaximal effort can be assessed reliably, and there is evidence that submaximal effort can be determined validly.[18,49] In addition, in future studies, the influence of workplace accommodation or familial support should be studied.

Study strengths

Strengths of this study are the range of known predictive variables consisting of self-reported measures, functional capacity tests, and insurance data, and a complete dataset of the outcome variable with 5 measurements over a period of 12 months.[32,50] Within the analytical approach we controlled for confounders and interactions. The participants, patients, and assessors of WC were blinded to the study hypotheses.[8]

Study limitations

Limitations are that the results of the FCE tests were accessible for the treating general practitioner, case manager, physiotherapist, and occupational physician and may have influenced their rating. Cointerventions during the time between 6 and 52 weeks were not controlled for, nor was type of work, which may be an important confounder for RTW and WC. The accuracy of self-reported measures for disability within a workers' compensation environment can be unreliable.[51,52] However, the alternative (WC) also has shortcomings; its psychometric properties are unknown, and WC is often reliant on patient reports and physician interpretations.[53] WC expressed as a percentage of workability of preinjury work is directly related to compensation costs and reflects the proportion of work loss to the employer, the employee, and the insurance. Therefore, this method of WC determination may be less subject to distortion compared with self-reported measures of WC. Nevertheless, this has not been studied yet. In light of the socioeconomic relevance of WC determination, there is an urgent need to validate currently used methods or validate new methods of WC determination. Finally, replication studies are

Table 2 Results of the linear mixed-model analysis with WC in % at 1, 3, 6, and 12 months after baseline assessment as the dependent variable (model steps/evolvement displayed)

Predictors Included in Steps 2 to 4	Coefficients (β)	SE (β)	95% CI	*P*
2. Model including effect of time and random effect				
Constant	−5.78	14.39	−34.10 to 22.55	.688
Repetitive reaching	−0.09	0.069	−0.22 to 0.05	.207
Walking speed	6.43	2.01	2.48 to 10.38	.002
S_{ED} score	−1.82	0.86	−3.52 to −0.12	.036
ln (weeks+1)	15.57	0.54	14.51 to 16.63	.000
3. Model including all predictors				
Constant	17.33	15.31	−12.77 to 47.43	.258
Repetitive reaching	−0.04	0.05	−0.15 to 0.06	.428
Walking speed	0.98	1.71	−2.37 to 4.33	.565
S_{ED} score	−0.06	0.77	−1.57 to 1.44	.936
ln (weeks+1)	14.68	0.66	13.39 to 15.97	.000
WC at baseline	0.57	0.05	0.46 to 0.67	.000
Mother language (Swiss-German 1, other 0)	3.48	3.05	−2.51 to 9.48	.254
No. of prior injuries	−0.20	0.32	−0.83 to 0.43	.533
Pain now (NRS)	−0.50	0.74	−1.96 to 0.96	.499
Perceived recovery (RQ)	0.92	2.99	−4.96 to 6.80	759
Perceived functional ability (SFS)	−0.00	0.05	−0.09 to 0.09	.935
Disability (NDI)	−0.41	0.28	−0.96 to 0.13	.132
Anxiety (HADS-A)	0.05	0.43	−0.80 to 0.89	.913
Depression (HADS-D)	−0.20	0.46	−1.10 to 0.71	.671
4. Model including interaction terms				
Constant	−0.60	7.08	−14.50 to 13.30	.933
ln (weeks+1)	23.74	2.39	19.04 to 28.44	.000
WC at baseline	1.01	0.07	0.86 to 1.15	.000
Mother language	5.49	2.47	0.64 to 10.34	.027
Disability (NDI)	−0.20	0.26	−0.70 to 0.30	.433
ln (weeks+1)* WC at baseline	−0.19	0.03	−0.24 to −0.14	.000
ln (weeks+1)* Disability (NDI)	−0.21	0.09	−0.38 to −0.04	.015

Abbreviations: β, unstandardized regression coefficient; CI, confidence interval; NRS, numeric rating scale; RQ, recovery question.

needed because the results differ in other populations, contexts, and with other FCE procedures.

Conclusions

FCE tests performed within 6 to 12 weeks after WADs injury grades I and II are associated with WC at baseline but do not predict future WC, whereas time course, mother language, WC at baseline, and self-reported disability do predict future WC. Additionally, the interaction between time course, WC at baseline, and self-reported disability mediated future WC.

Suppliers

a. IBM Corp, 1 New Orchard Rd, Armonk, NY 10504-1722.
b. Sammons Preston Rolyan, 4 Sammons Crt, Bolingbrook, IL 60440.

Keywords

Disability evaluation; Neck pain; Prognosis; Rehabilitation; Return to work; Whiplash injuries

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Appendix 1. FCE Test Details

FCE test procedure and patient instructions

Patients were briefly instructed on how to perform each test. The assessor first gave a single demonstration of each test. Lifting tests were commenced with a light weight. Patients were then asked to perform the tests to their maximum ability. Weights lifted incrementally increased according to a patient's performance, using weights of 2.5 and 5kg. To determine the physical effort level, testers used observational criteria indicating physical demand.[13] Testing could be terminated for 4 reasons: (1) the patient stopped because of, for example, pain; (2) the assessor deemed testing to have become unsafe based on biomechanical criteria; (3) the heart rate exceeded 85% of the age-related maximum (220 minus age of patient); or (4) a predefined time limit was reached. If a patient stopped the lifting waist-to-overhead test before the criteria for maximum level of demand was observed, the highest weight in kilograms that the patient was willing to lift 5 times was recorded.

FCE test descriptions

Isometric hand grip strength

Isometric hand grip strength was measured in a seated position. The subjects held their shoulder adducted without internal or external rotation, elbow flexed at approximately 90°, and the forearm and wrist in the neutral position. Grip strength of the right and left hand was measured in a 3-trial procedure while maintaining in a hand dynamometer in a 1 handgrip position (Jamar PC 5030[b]). An average amount of kilogram-force was scored.

Material handling tests

All lifting tests were executed with a wooden crate (40×30×26cm) of 2.5kg, and 4 to 5 weight increments of 2.5kg or 5kg each were used until the maximum amount of weight was reached. Maximum performance was recorded in kilograms.

Lifting floor to waist was measured after 5 lifts of the crate from floor to table and vice versa (time limit <90s); hands remained on the crate during the test.

Lifting waist to overhead was measured during lifting of the crate from table to crown in standing position, and vice versa.

Two-handed carrying of a crate for a short distance was measured after 5 carries of 1.5m distance at waist height. Hands remained on the crate during the test.

The 1-handed carrying of a wooden crate for 15m within 40 seconds began with the right hand and thereafter the left hand.

Overhead work test

Overhead working was performed standing with hands at crown height for manipulation of nuts and bolts. The time that the position was held was recorded (s).

Repetitive reaching test

Repetitive reaching was determined by fast horizontal movements of the upper extremity in a sitting position. Marbles were removed from bowls at arm length distance at table height from left to right and vice versa, with right and then left arm. The time taken to remove 30 marbles was recorded (s).

50-m walking test

The walking test was executed on a 50-m distance track. Participants were asked to walk as fast as possible. The instruction was: "Pause is allowed. Do not run!" The time taken to walk for 50m was measured (s), and kilometers per hour was calculated.

Appendix 2. Clinical Examples for Interpreting Results of the Linear Mixed-Model Analysis

Clinical Examples
Formula derived from model 3 in table 2:
WC (%) = .60 + (23.74 × ln (weeks+1) + (1.01 × WC baseline) + (5.49 × mother language) + (−.20 × self-reported disability NDI) + (−.19 × ln (weeks+1) × WC in % at baseline) + (−.21 × ln (weeks+1) × self-reported disability, NDI)
Example A: Moderately disabled patient at baseline
Prediction of WC after: 2 weeks from baseline
WC: 60% at baseline
Mother language: 1, German
NDI score: 15
WC = −.60 + (23.74 × ln (weeks+1) + (1.01 × WC) + (5.49 × mother language) + (−.20 × self-reported disability NDI) + (−.19 × ln (weeks+1) × WC in % at baseline) + (−.21 × ln (weeks+1) × self-reported disability)
WC = −.60 + (23.74 × ln 3) + (1.01 × 60) + (5.49 × 1) + (−.20 × 15) + (−.19 × ln 3 × 60) + (−.21 × ln 3 × 15) = **72.2%**
Example B: Severely disabled patient at baseline
Prediction of WC after: 10 weeks from baseline
WC: 10% at baseline
Mother language: 0, non German
NDI score: 40
WC = −.60 + (23.74 × ln (weeks+ 1) + (1.01 × WC) + (5.49 × mother language) + (−.20 × self-reported disability NDI) + (−.19 × ln (weeks+1) × WC in % at baseline) + (−.21 × ln (weeks+1) × self-reported disability)
WC = −.60 + (23.74 × ln 11) + (1.01 × 10) + (5.49 × 0) + (−.20 × 40) + (−.19 × ln 11 × 10) + (−.21 × ln 11 × 40) = **33.4%**

References

1. Carroll LJ, Hogg-Johnson S, Cote P, et al. Course and prognostic factors for neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine (Phila Pa 1976) 2008;33(4 Suppl):S93-100.
2. Kamper SJ, Rebbeck TJ, Maher CG, McAuley JH, Sterling M. Course and prognostic factors of whiplash: a systematic review and meta-analysis. Pain 2008;138:617-29.
3. Chappuis G, Soltermann B. Number and cost of claims linked to minor cervical trauma in Europe: results from the comparative study by CEA, AREDOC and CEREDOC. Eur Spine J 2008;17:1350-7.
4. Scholten-Peeters GG, Verhagen AP, Bekkering GE, et al. Prognostic factors of whiplash-associated disorders: a systematic review of prospective cohort studies. Pain 2003;104:303-22.
5. Williamson E, Williams M, Gates S, Lamb SE. A systematic literature review of psychological factors and the development of late whiplash syndrome. Pain 2008;135:20-30.
6. Carroll LJ, Ferrari R, Cassidy JD, Cote P. Coping and recovery in whiplash-associated disorders: early use of passive coping strategies is associated with slower recovery of neck pain and pain-related disability. Clin J Pain 2014;30:1-8.
7. Holm LW, Carroll LJ, Cassidy JD, Skillgate E, Ahlbom A. Expectations for recovery important in the prognosis of whiplash injuries. PLoS Med 2008;5:e105.
8. Kamper SJ, Hancock MJ, Maher CG. Optimal designs for prediction studies of whiplash. Spine (Phila Pa 1976) 2011;36(25 Suppl): S268-74.
9. Lin CW, McAuley JH, Macedo L, Barnett DC, Smeets RJ, Verbunt JA. Relationship between physical activity and disability in low back pain: a systematic review and meta-analysis. Pain 2011; 152:607-13.
10. Annet L, Ilona Z. Review on the validity and reliability of self-reported work-related illness. London: Health and Safety Executive; 2012.
11. Isernhagen SJ. Functional capacity evaluation: rational, procedure, utility of the kinesiophysical approach. J Occup Rehabil 1992;2: 157-68.
12. Henchoz Y, de Goumoens P, Norberg M, Paillex R, So AK. Role of physical exercise in low back pain rehabilitation: a randomized controlled trial of a three-month exercise program in patients who have completed multidisciplinary rehabilitation. Spine (Phila Pa 1976) 2010;35:1192-9.
13. Kool JP, Oesch PR, Bachmann S, et al. Increasing days at work using function-centered rehabilitation in nonacute nonspecific low back pain: a randomized controlled trial. Arch Phys Med Rehabil 2005;86: 857-64.
14. Oesch PR, Kool JP, Bachmann S, Devereux J. The influence of a functional capacity evaluation on fitness for work certificates in patients with non-specific chronic low back pain. Work 2006;26: 259-71.
15. Wind H, Gouttebarge V, Kuijer PP, Sluiter JK, Frings-Dresen MH. Effect of functional capacity evaluation information on the judgment of physicians about physical work ability in the context of disability claims. Int Arch Occup Environ Health 2009;82:1087-96.
16. Suva. Suva: an overview [Swiss Accident Insurance Fund] 2013. Available at: http://www.suva.ch/english/startseite-en-suva/suva-en-suva/ueberblick-en-suva.htm. Accessed September 9, 2013.
17. Denier-Bont F, Fischer V, Oesch P, Oliveri M. [Functional capacity evaluation: course manual] [German]. Bellikon: Verein IG Ergonomie, Swiss Association of Rehabilitation; 2007.
18. Trippolini MA, Dijkstra PU, Jansen B, Oesch P, Geertzen JH, Reneman MF. Reliability of clinician rated physical effort determination during functional capacity evaluation in patients with chronic musculoskeletal pain. J Occup Rehabil 2014;24:361-9.
19. Stöckli H, Ettlin T, Gysi F, Knüsel O, Marelli R, Soltermann B. [Diagnostics and therapeutic approach in the chronic phase of whiplash associated disorders] [German]. Schweiz Med Forum 2005; 5:1182-1187.
20. Fitforwork-swiss. WOCADO [Workcapacity estimation for doctors] [German]. 2013. Available at: http://www.fitforwork-swiss.ch/de/projekte.html. Accessed March 12, 2013.
21. Trippolini MA, Reneman MF, Jansen B, Dijkstra PU, Geertzen JH. Reliability and safety of functional capacity evaluation in patients with whiplash associated disorders. J Occup Rehabil 2013;23:381-90.
22. Ferraz MB, Quaresma MR, Aquino LR, Atra E, Tugwell P, Goldsmith CH. Reliability of pain scales in the assessment of literate and illiterate patients with rheumatoid arthritis. J Rheumatol 1990; 17:1022-4.
23. Pool JJ, Ostelo RW, Hoving JL, Bouter LM, de Vet HC. Minimal clinically important change of the Neck Disability Index and the numerical rating scale for patients with neck pain. Spine (Phila Pa 1976) 2007;32:3047-51.
24. Carroll LJ, Holm LW, Ferrari R, Ozegovic D, Cassidy JD. Recovery in whiplash-associated disorders: do you get what you expect? J Rheumatol 2009;36:1063-70.
25. Ngo T, Stupar M, Cote P, Boyle E, Shearer H. A study of the test-retest reliability of the self-perceived general recovery and self-perceived change in neck pain questions in patients with recent whiplash-associated disorders. Eur Spine J 2010;19:957-62.
26. Swanenburg J, Humphreys K, Langenfeld A, Brunner F, Wirth B. Validity and reliability of a German version of the Neck Disability Index (NDI-G). Man Ther 2014;19:52-8.
27. Bjelland I, Dahl AA, Haug TT, Neckelmann D. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. J Psychosom Res 2002;52:69-77.
28. U.S. Department of Labor. The revised handbook for analyzing jobs. 4th ed. Indianapolis: JIST Works; 1991.
29. Oesch PR, Hilfiker R, Kool JP, Bachmann S, Hagen KB. Perceived functional ability assessed with the Spinal Function Sort: is it valid for European rehabilitation settings in patients with non-specific non-acute low back pain? Eur Spine J 2010;19:1527-33.
30. Borloz S, Trippolini MA, Ballabeni P, Luthi F, Deriaz O. Cross-cultural adaptation, reliability, internal consistency and validation of the Spinal Function Sort (SFS) for French- and German-speaking patients with back complaints. J Occup Rehabil 2012;22:387-93.
31. Sterling M. Does knowledge of predictors of recovery and non-recovery assist outcomes after whiplash injury? Spine (Phila Pa 1976) 2011;36(25 Suppl):S257-62.
32. Nordin M, Carragee EJ, Hogg-Johnson S, et al. Assessment of neck pain and its associated disorders: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine (Phila Pa 1976) 2008;33(4 Suppl):S101-22.
33. Ronda Perez E, Benavides FG, Levecque K, Love JG, Felt E, Van Rossem R. Differences in working conditions and employment arrangements among migrant and non-migrant workers in Europe. Ethn Health 2012;17:563-77.
34. McCauley LA. Immigrant workers in the United States: recent trends, vulnerable populations, and challenges for occupational health. AAOHN J 2005;53:313-9.
35. Sloots M, Dekker JH, Bartels EA, Geertzen JH, Dekker J. Reasons for drop-out in rehabilitation treatment of native patients and non-native patients with chronic low back pain in the Netherlands: a medical file study. Eur J Phys Rehabil Med 2010;46:505-10.
36. Luthi F, Deriaz O, Vuistiner P, Burrus C, Hilfiker R. Predicting non return to work after orthopaedic trauma: the Wallis Occupational Rehabilitation RisK (WORRK) model. PLoS One 2014;9:e94268.
37. Franzen J, Mantwill S, Rapold R, Schulz PJ. The relationship between functional health literacy and the use of the health system by diabetics in Switzerland. Eur J Public Health 2013 Dec 23 [Epub ahead of print].
38. Kuijer PP, Gouttebarge V, Brouwer S, Reneman MF, Frings-Dresen MH. Are performance-based measures predictive of work participation in patients with musculoskeletal disorders? A systematic review. Int Arch Occup Environ Health 2011;85:109-23.

39. Branton EN, Arnold KM, Appelt SR, Hodges MM, Battie MC, Gross DP. A short-form functional capacity evaluation predicts time to recovery but not sustained return-to-work. J Occup Rehabil 2010; 20:387-93.
40. Kuijer PP, Gouttebarge V, Wind H, van Duivenbooden C, Sluiter JK, Frings-Dresen MH. Prognostic value of self-reported work ability and performance-based lifting tests for sustainable return to work among construction workers. Scand J Work Environ Health 2012;38:600-3.
41. Streibelt M, Blume C, Thren K, Reneman MF, Mueller-Fahrnow W. Value of functional capacity evaluation information in a clinical setting for predicting return to work. Arch Phys Med Rehabil 2009;90:429-34.
42. Gross DP, Battie MC. Functional capacity evaluation performance does not predict sustained return to work in claimants with chronic back pain. J Occup Rehabil 2005;15:285-94.
43. Lechner DE, Page JJ, Sheffield G. Predictive validity of a functional capacity evaluation: the physical work performance evaluation. Work 2008;31:21-5.
44. Cheng AS, Cheng SW. The predictive validity of job-specific functional capacity evaluation on the employment status of patients with nonspecific low back pain. J Occup Environ Med 2010;52:719-24.
45. Reneman MF, Dijkstra PU. Predictive validity of FCE? Work 2009; 32:105-6. author reply 107-108.
46. Reneman MF, Soer R. Was predictive validity of a job-specific FCE established? J Occup Environ Med 2010;52:1145. author reply 1145-1146.
47. Gross DP, Asante AK, Miciak M, et al. A cluster randomized clinical trial comparing functional capacity evaluation and functional interviewing as components of occupational rehabilitation programs. J Occup Rehabil 2013 Dec 29 [Epub ahead of print].
48. Fishbain DA, Cutler R, Rosomoff HL, Rosomoff RS. Chronic pain disability exaggeration/malingering and submaximal effort research. Clin J Pain 1999;15:244-74.
49. van der Meer S, Trippolini MA, van der Palen J, Verhoeven J, Reneman MF. Which instruments can detect submaximal physical and functional capacity in patients with chronic nonspecific back pain? A systematic review. Spine (Phila Pa 1976) 2013;38: E1608-15.
50. Sterling M, Carroll LJ, Kasch H, Kamper SJ, Stemper B. Prognosis after whiplash injury: where to from here? Discussion paper 4. Spine (Phila Pa 1976) 2011;36(25 Suppl):S330-4.
51. Gauthier N, Sullivan MJ, Adams H, Stanish WD, Thibault P. Investigating risk factors for chronicity: the importance of distinguishing between return-to-work status and self-report measures of disability. J Occup Environ Med 2006;48:312-8.
52. Don AS, Carragee EJ. Is the self-reported history accurate in patients with persistent axial pain after a motor vehicle accident? Spine J 2009;9:4-12.
53. Rainville J, Pransky G, Indahl A, Mayer EK. The physician as disability advisor for patients with musculoskeletal complaints. Spine (Phila Pa 1976) 2005;30:2579-84.